Life Cycle Cost Analysis

Review and Examples

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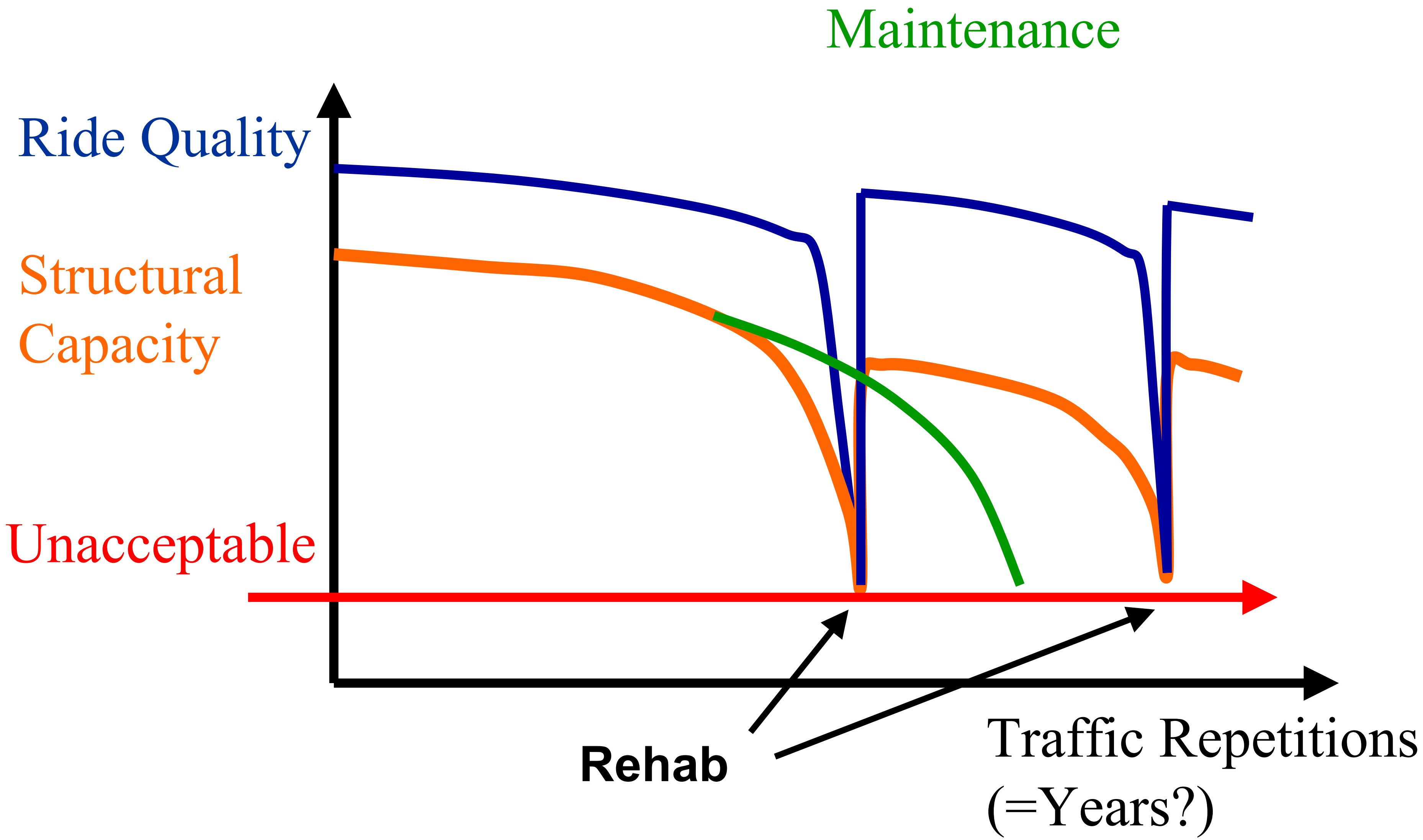
Pavement Performance (Life) Curve



Generic LCCA – Input

- Initial Traffic and Traffic Growth Rate
- Performance Curve – <u>use local service life information</u>
- Cost
  - Agency costs
  - User costs – work zone delay cost only
- Salvage Values
- Analysis Period
  - must be same for present value analysis
  - use equiv uniform annual cost if different
- Discount Rate
  - use the official rate

Table 605.3
Life-Cycle Economic Comparison of Pavement Types
(Variable-Year Analysis Period and 4% Discount Rate)

ALTERNATIVE 1			Cost Per Kilometer With Shoulders
Initial Cost =			$(_A_)
Rehabilitation Costs in Year _____:			
Repair Cost =		$(_b_)	
Engineering	$(_b_)(0.1225) =	$(___)	
Appurtenant and Supplemental Work	$(_b_)(0.1350) =	$(___)	
Traffic Delay =		$(___)	
		$(_c_)	
Present Worth Cost of Rehabilitation Work in Year ____		$(_c_) (PWF) =	$(_C_)
Rehabilitation Costs in Year _____: ****			
Repair Cost =		$(_d_)	
Engineering	$(_d_)(0.1225) =	$(___)	
Appurtenant and Supplemental Work	$(_d_)(0.1350) =	$(___)	
Traffic Delay =		$(___)	
		$(_e_)	
Present Worth Cost of Rehabilitation Work in Year ____		$(_e_) (PWF) =	$(_E_)
Annual/Average Maintenance over ____ years (See Index 605.3(2)(b))		$(_*_)(16.3742)=	$(_F_)
Subtotal (A+C+E+F)			$(___)
Less Salvage Value (of rehabilitation)**		(Variable Ratio) $(_c_)(PWF) =	- $(___)
C Pavement Net Present Worth Cost			$(___)

For both new pavement and rehab!
Doesn't assume 20 year life

Continuously Reinforced Concrete Pavement

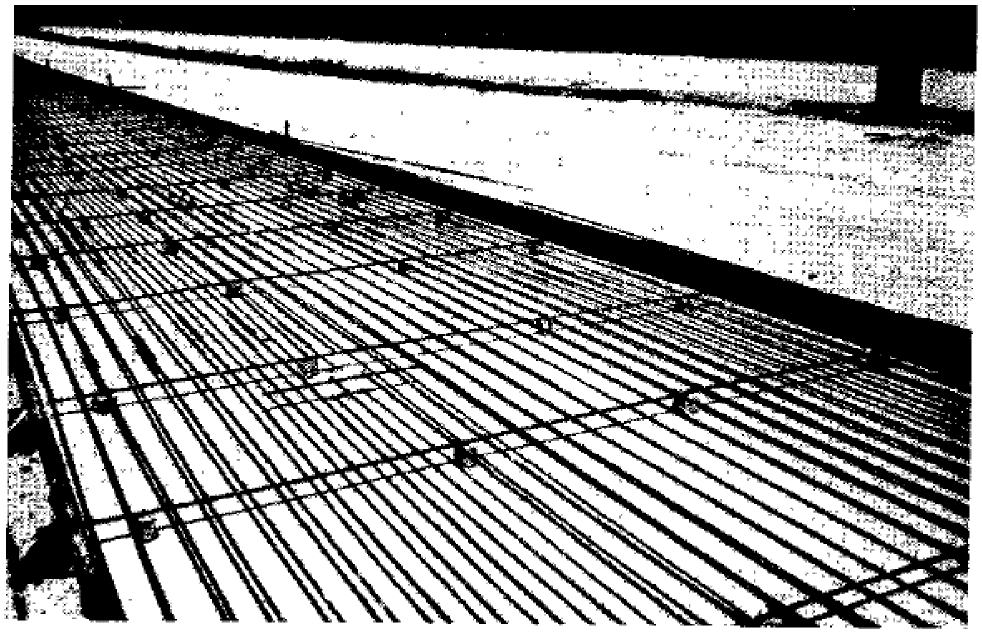


Fig. 4 Reinforcing Steel in place on base

Fairfield, CA

I-80 (old US 40)

WB, lanes 1 and 2

Test section

Service life (55 years):

initial construction 1949

repair localized problems

lane 2 grind in 1990s

"…reinforcement to control cracking is probably not economical and cannot be justified *unless* an equivalent benefit is attained with relation to long-time riding qualities and greater durability…"

T. Stanton, 1951

Post-constr. report: www.dot.ca.gov/hq/research/researchreports/5/reports/51-05.pdf

Example of Building Life Cycle Cost Diagram

Note: costs and performance are estimates from Oregon DOT, for example purposes only

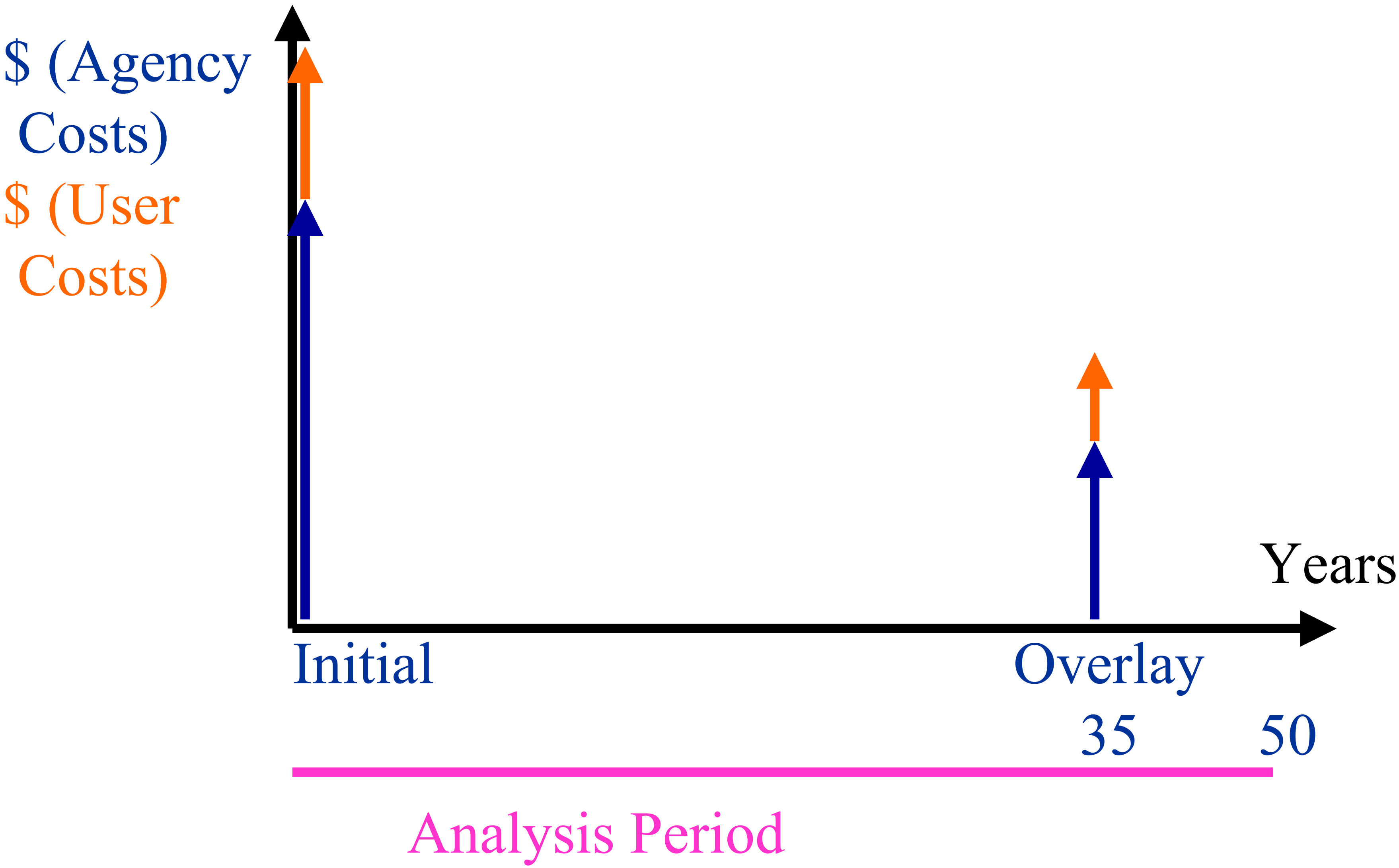
<u>**Continuously Reinforced Concrete Pavement (CRC)**</u>

Initial Cost about 1.25 to 1.5 x current PCCP

Life cycle:

- **initial construction**
- **AC overlay at 35 to 55 years on major freeways**

CRC Example – 35 year service life



Example of Building Life Cycle Cost Diagram

Note: costs and performance are estimates from Oregon DOT, for example purposes only

Continuously Reinforced Concrete Pavement (CRC)

Initial Cost about 1.25 to 1.5 x current PCCP

Life cycle:

- **initial construction**
- **AC overlay at end of service life**

What Happens if We Use Inappropriate Service Life in LCCA?

Assumed Life	PV	Equiv Annual Cost
20 yrs	$ 28,123,000	$ 1,718,000
Analysis period 35 years		
35 yrs	$ 26,853,000	$ 1,511,000
Analysis period 45 years		12 % less!
55 yrs	$ 26,119,000	$ 1,363,000
Analysis period 65 years		21 % less!!

Had to use Equivalent Uniform Annual Cost because have different analysis periods

How Do We Know What the Performance Will Be?

Traffic and traffic growth projections

Climate predictions

Performance prediction

Another Example: Grind JPC vs ACOL
(estimated numbers again, 20 year analysis period)

Assumed Life	PV	Equiv Annual Cost
Grind lasts 15 years, then ACOL lasts 10 years		
	$ 4,704,000	$ 377,000
Grind lasts 8 years, then two ACOLS each 10 years		
	$ 7,940,000	$ 637,000
ACOL lasts 10 years, then 2nd ACOL lasts 10 years		
	$ 10,482,000	$ 841,000
Three ACOLs, each lasting 7 years		
	$ 14,390,000	$ 1,155,000

Cost Source: 2003 State of the Pavement report

Performance estimated, assume 30 ln-km project

Pavement Strategy Selection

Is Life Cycle Cost the only criterion?

- Construction constraints
- Compatibility with existing structures
- Performance constraints
- Maintenance constraints
- other constraints

Summary

- Use best estimate of local service lives (concrete CAN be much greater than 20 years)
- LCCA is a powerful tool for comparing alternatives for BOTH new construction and rehab
- If comparing short lives with long lives, use Equivalent Uniform Annual Cost, not Present Value

Thank You

Present Value Equations

Single cost

$$P = F * [1/(1 + i)^n]$$

distributed cost

$$P = A * \{[(1+i)^n - 1] / [i(1+i)^n]\}$$

Equivalent Uniform Annual Cost

A=P{i[1+i]^n}/{[(1+i)^n-1]}